Investigation of an epidemic of Food Poisoning

Basic Epidemiology

Screening and its Useful Tools

Learning Objectives

1. Define screening
2. Describe its purpose and usefulness
3. Describe the process of screening
4. Enumerate the criteria of a good screening test and explain each one in detail with suitable examples

Screening

- **The early detection of**
  - **disease**
  - **precursors of disease**
  - **susceptibility to disease**

  in individuals who do not show any signs of disease

Goel

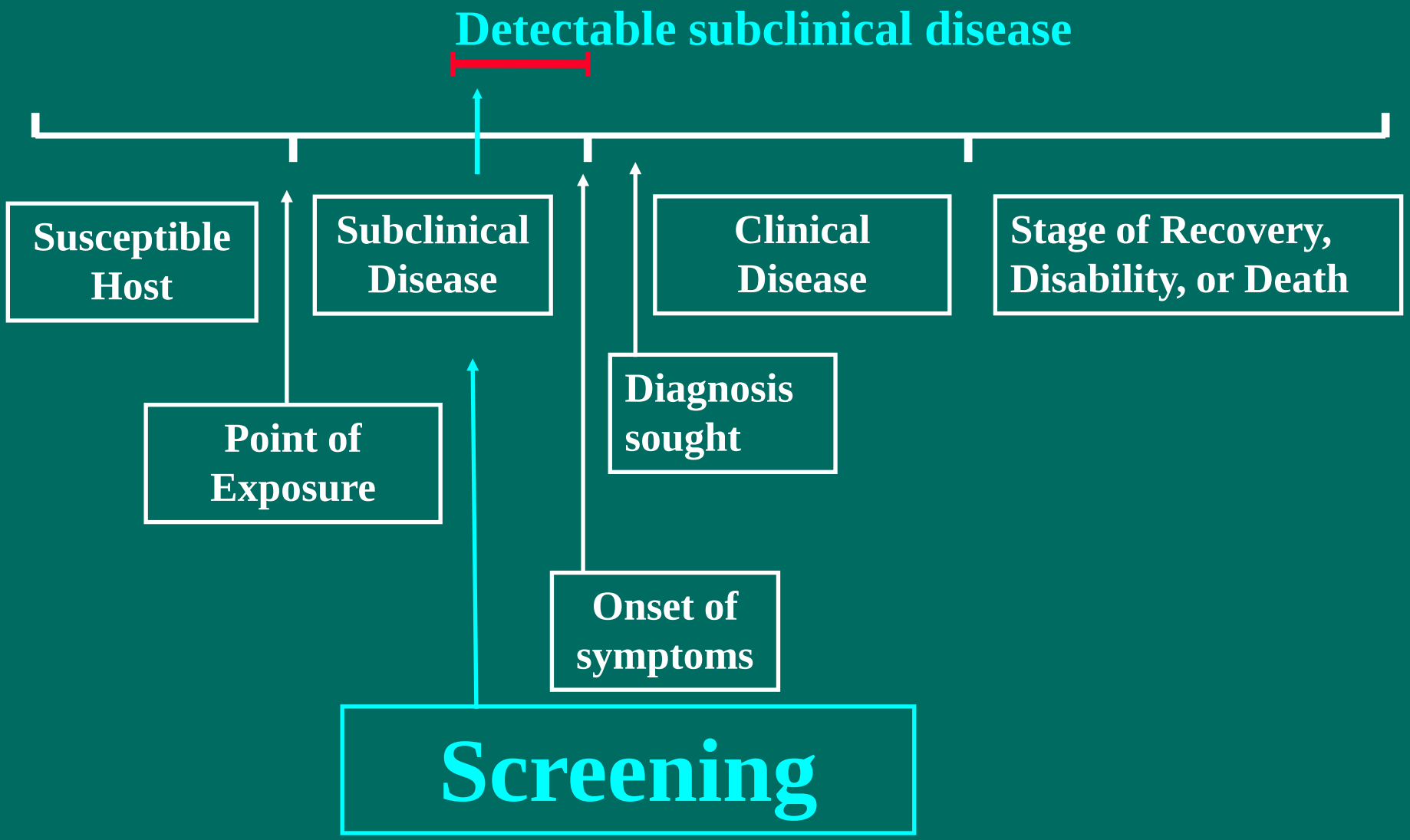
Purpose of Screening

- **Aims to reduce morbidity and mortality from disease among persons being screened**
- **Is the application of a relatively simple, inexpensive test, examinations or other procedures to people who are asymptomatic, for the purpose of classifying them with respect to their likelihood of having a particular disease**
- **a means of identifying persons at increased risk for the presence of disease, who warrant further evaluation**

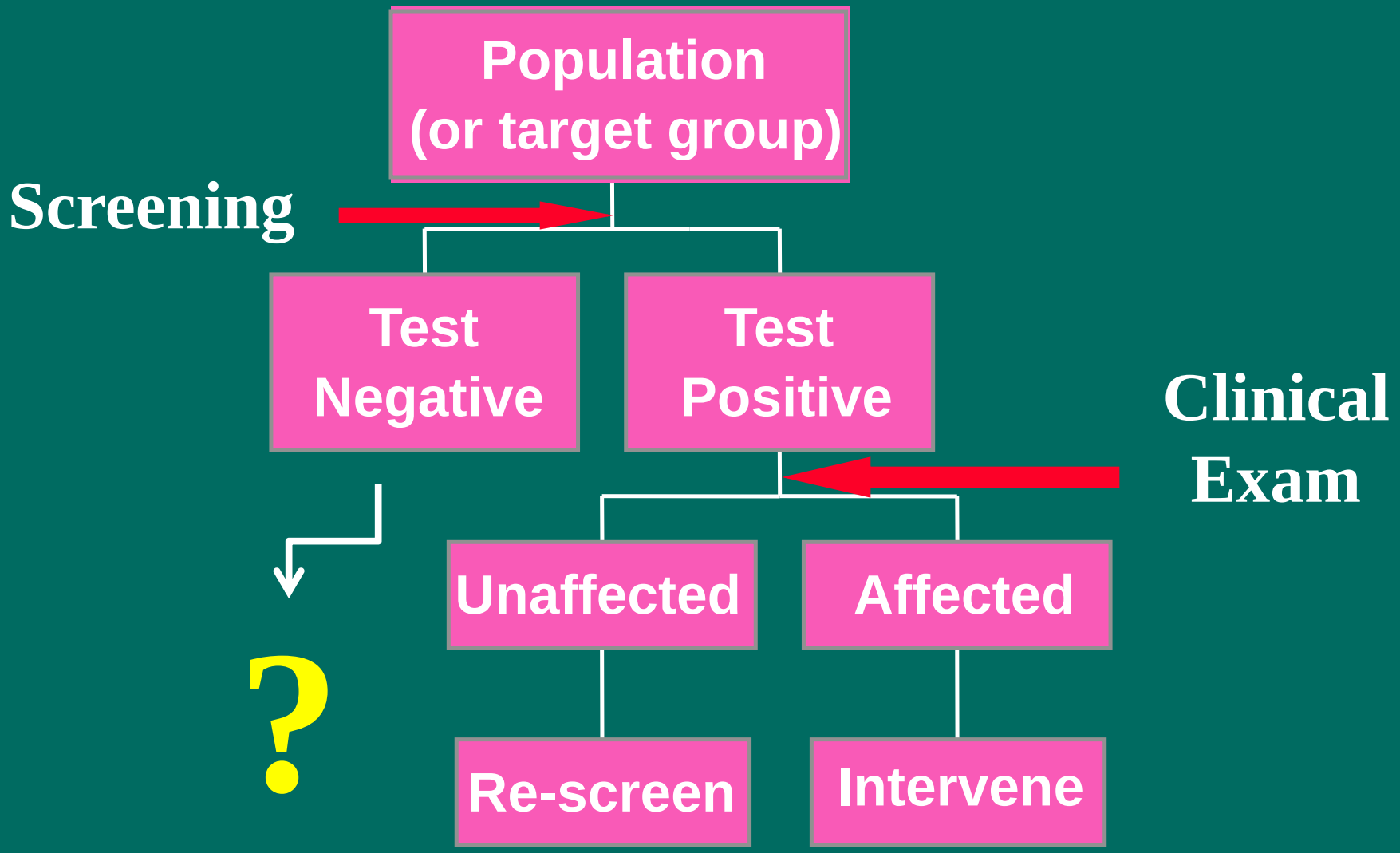
Diagnosis ≠ Screening

- Screening tests can also often be used as diagnostic tests
- Diagnosis involves confirmation of presence or absence of disease in someone suspected of or at risk for disease
- Screening is generally done among individuals who are not suspected of having disease

Natural History of Disease



Screening Process



Examples of Screening Tests

- Questions
- Clinical Examinations
- Laboratory Tests
- Genetic Tests
- X-rays

Goel

Validity of Screening Tests

Key Measures

- Sensitivity
- Specificity
- Positive Predictive Value
- Negative Predictive Value

(Acceptability, repeatability)

Terminology

Validity is analogous to accuracy

The validity of a screening test is how well the given screening test reflects *another* test of known greater accuracy

Validity assumes that there is a gold standard to which a test can be compared

Paneth

Disease

Screening Test	Present	Absent	
Positive	a	b	a + b
Negative	c	d	c + d
	a + c	b + d	N

Screening Test	Disease: Present	Disease: Absent
Positive	True positives	False positives
Negative	False negatives	True negatives

Sensitivity

- **Proportion of individuals who have the disease who test positive (a.k.a. true positive rate)**
- **tells us how well a "+" test picks up disease**

Screening Test	Disease: yes	Disease: no	
+	a	b	a + b
-	c	d	c + d
	a + c	b + d	N

$$\text{Sensitivity} = \frac{a}{a + c}$$

Specificity

- **Proportion of individuals who don't have the disease who test negative (a.k.a. true negative rate)**
- **tell us how well a "-" test detects no disease**

Screening Test	Disease: yes	Disease: no	
+	a	b	a + b
-	c	d	c + d
	a + c	b + d	N

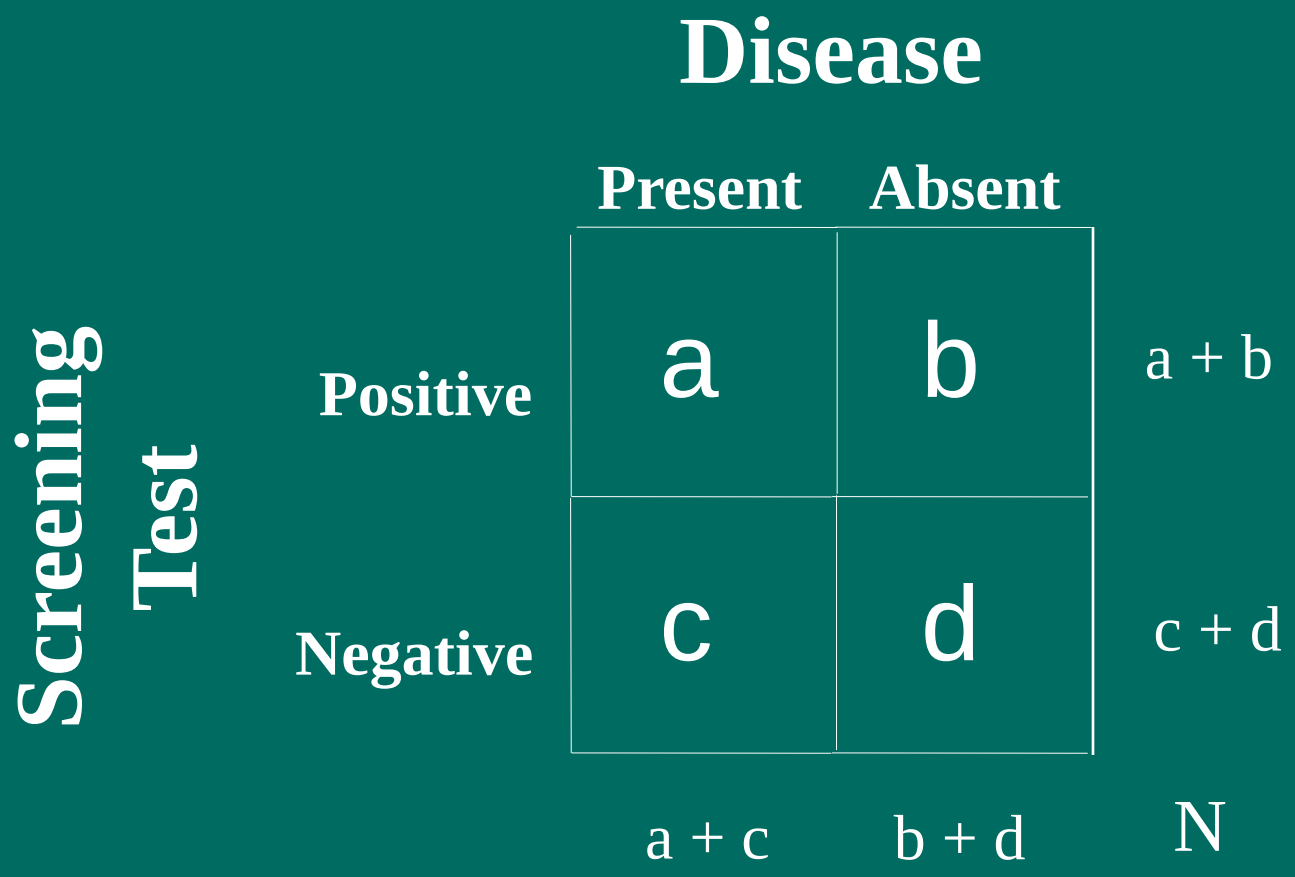
$$\text{Specificity} = \frac{d}{b + d}$$

Screening Principles

- **Sensitivity**
  - the ability of a test to correctly identify those who have a disease
    - a test with high sensitivity will have few false negatives
- **Specificity**
  - the ability of a test to correctly identify those who do not have the disease
    - a test that has high specificity will have few false positives

Predictive Value

- Measures whether or not an individual actually has the disease, given the results of a screening test
- Affected by
  - specificity
  - prevalence of preclinical disease
  - Sensitivity
- Prevalence = $\frac{a + c}{a + b + c + d}$


Disease
Present
Absent
Screening Test
Positive
Negative
a
b
c
d
a + b
c + d
a + c
b + d
N

Positive Predictive Value

- Proportion of individuals who test positive who actually have the disease

Screening Test	Disease: yes	Disease: no	
+	a	b	a + b
-	c	d	c + d
	a + c	b + d	N

$$\text{P.P.V.} = \frac{a}{a + b}$$

Negative Predictive Value

- Proportion of individuals who test negative who don't have the disease

Screening Test	Disease: yes	Disease: no	
+	a	b	a + b
-	c	d	c + d
	a + c	b + d	N

$$\text{N.P.V.} = \frac{d}{c + d}$$

A test is used in 50 people with disease and 50 people without. These are the results.

Screening Test	Disease: Present	Disease: Absent	
Positive	48	3	51
Negative	2	47	49
	50	50	100

Paneth

Screening Test	Disease: Present	Disease: Absent	
Positive	48	3	51
Negative	2	47	49
	50	50	100

Sensitivity = 48/50

Specificity = 47/50

Positive Predictive Value = 48/51

Negative Predictive Value = 47/49

Paneth

So… you understand the accuracy of a screening test …

What is the next step?

Put screening to use in the population

Considerations in Screening

Severity

Prevalence

Understand Natural History

Diagnosis & Treatment

Cost

Efficacy

Safety

Criteria for a Successful Screening Program

- Disease
  - present in population screened
  - high morbidity or mortality; must be an important public health problem
  - early detection and intervention must improve outcome

Criteria for a Successful Screening Program

- **Disease**
  - **The natural history of the disease should be understood, such that the detectable sub-clinical disease stage is known and identifiable**

Criteria for a Successful Screening Program

- **Screening Test**
  - **should be relatively sensitive and specific**
  - **should be simple and inexpensive**
  - **should be very safe**
  - **must be acceptable to subjects and providers**

Criteria for a Successful Screening Program

- **Have an Exit Strategy**
  - **Facilities for diagnosis and appropriate treatments should be available for individuals who screen positive**
  - **It is unethical to offer screening when no services are available for subsequent treatment**

Screening Strategies

High-Risk Strategy

- Cost-effective
- Intervention appropriate to the individual
- Fails to deal with the root causes of disease
- Subjects motivated
- Small chance of reducing disease incidence

Population Approach

- Potential to alter the root causes of disease
- Large chance of reducing disease incidence
- Small benefit to the individual
- Poor subject motivation
- Problematic risk-benefit ratio

Screening is not always free of risk

In population screening….

False positives tend to swamp true positives in populations, because most diseases we test for are rare

Paneth

Risks of Screening

- True Positives
  - "labeling effect" (classified as diseased from the time of the test forward)
- False Positives
  - anxiety
  - fear of future tests
  - monetary expense

Risks of Screening

- **False Negatives**
  - **delayed intervention**
  - **disregard of early signs or symptoms which may lead to delayed diagnosis**

- **When to use a highly sensitive test**
- **When to use a highly specific test**

Volunteer bias

- Type of bias where those who choose to participate are likely to be different from those who don't
- Volunteers tend to have:
  - Better health
  - Lower mortality
  - Likely to adhere to prescribed medical regimens